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**Bahramian**

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- (54) **LOW PROFILE LIGHT PANEL**
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- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 423 days.

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- (21) Appl. No.: **11/136,511**
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(63) Continuation-in-part of application No. 10/633,548, filed on Aug. 5, 2003, now Pat. No. 7,048,398, which is a continuation of application No. 29/198,736, filed on Feb. 5, 2004, and a continuation of application No. 10/724,181, filed on Dec. 1, 2003.

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**F21V 8/00** (2006.01)
- (52) **U.S. Cl.** ..... **362/613**; 362/555; 362/612; 362/615; 362/629; 362/628
- (58) **Field of Classification Search** ..... 362/555, 362/800, 613, 611, 561, 612, 311, 330, 235, 362/244, 245, 246, 615, 628, 629  
See application file for complete search history.

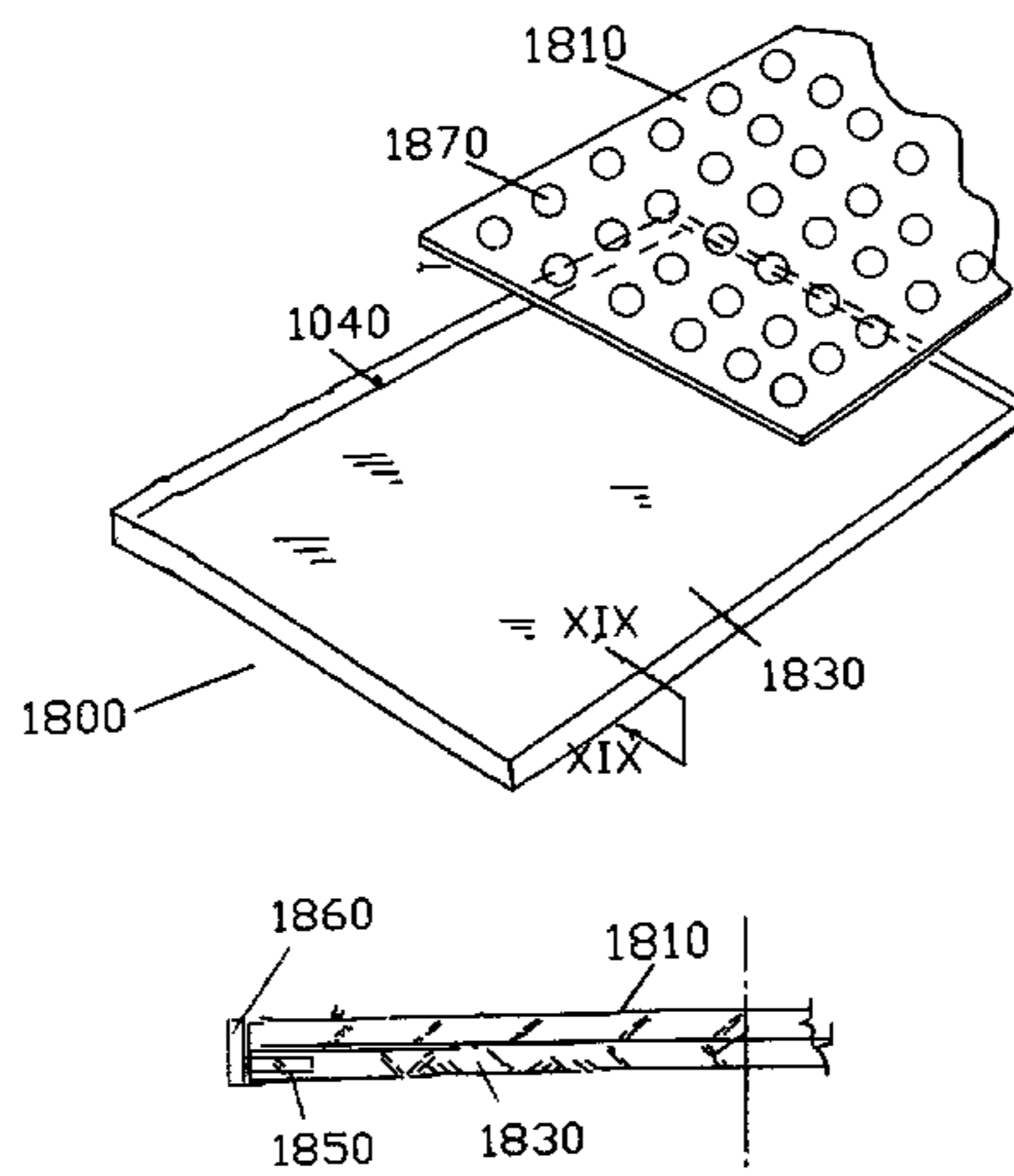
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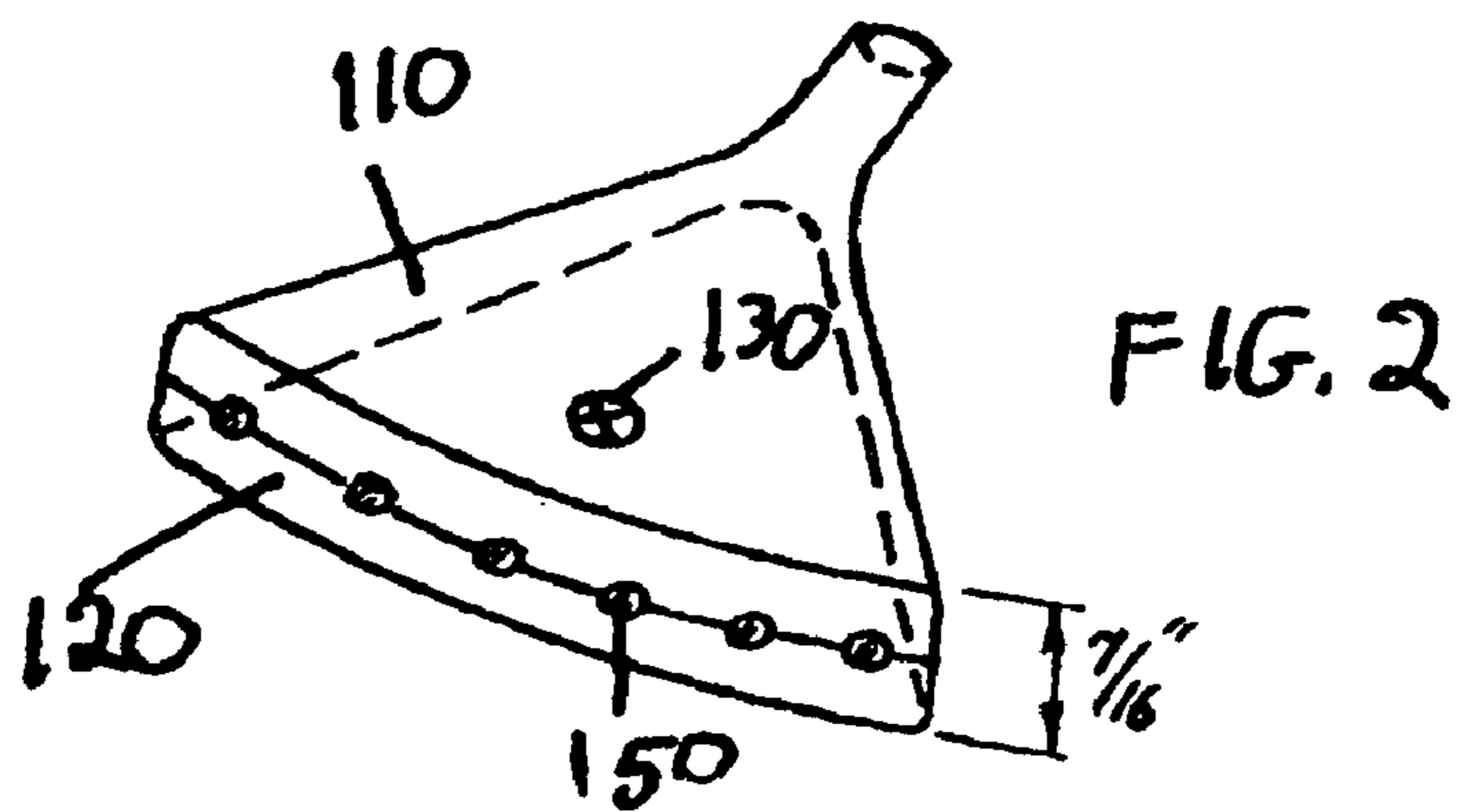
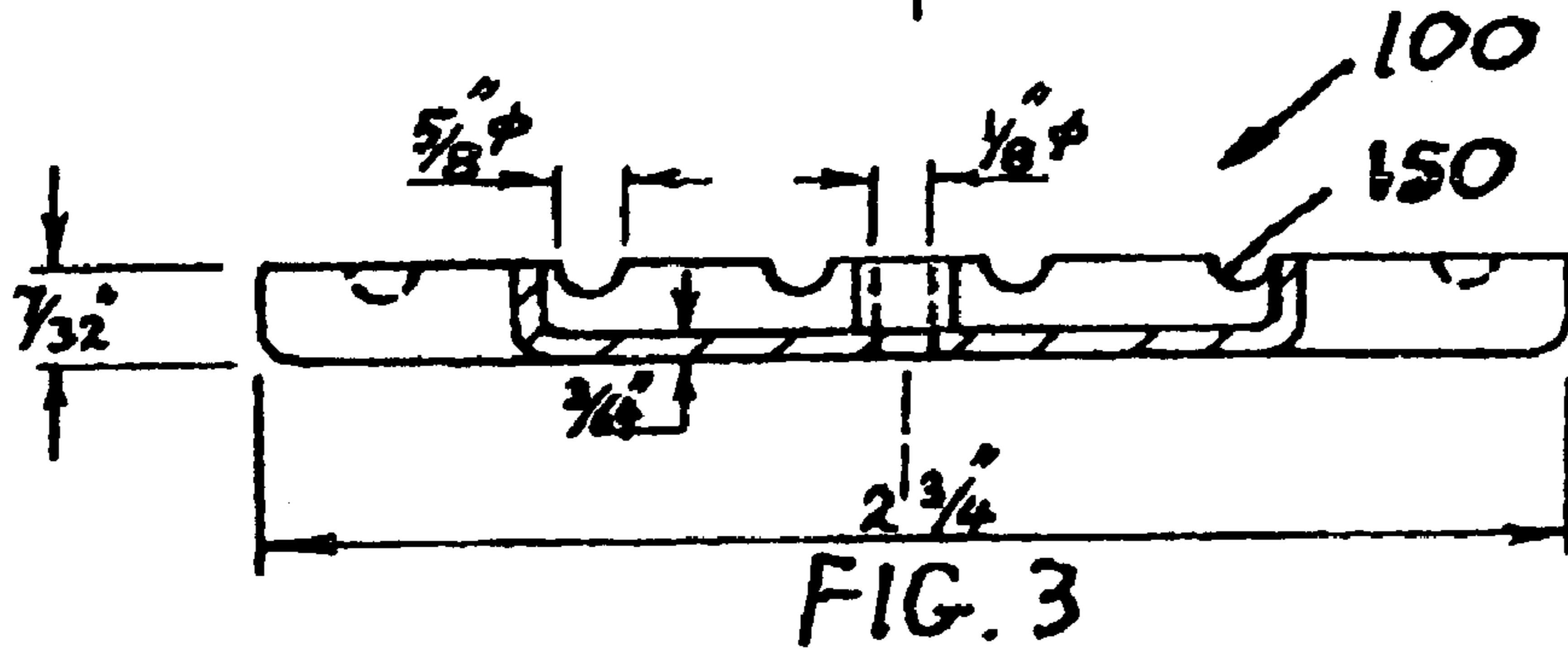
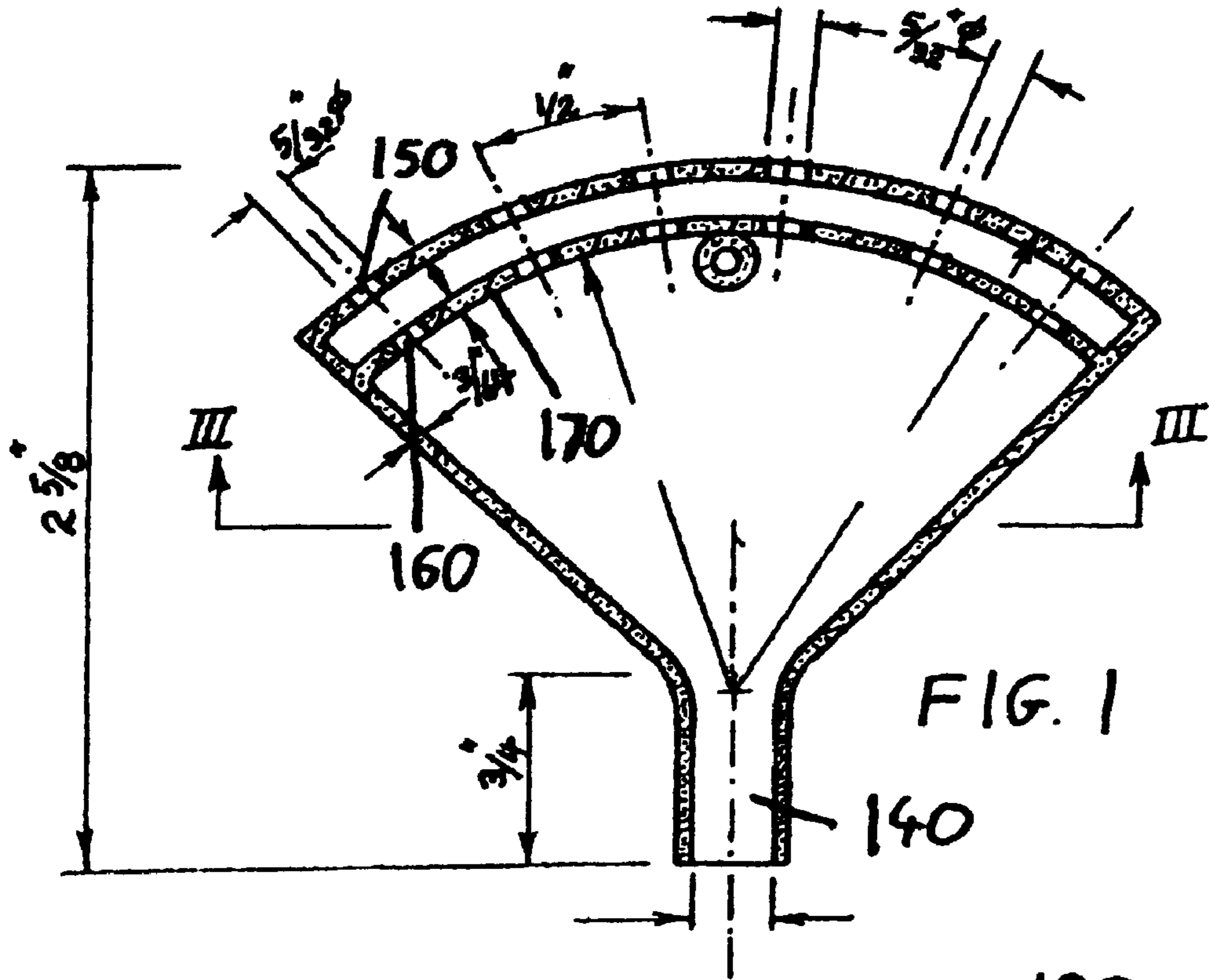
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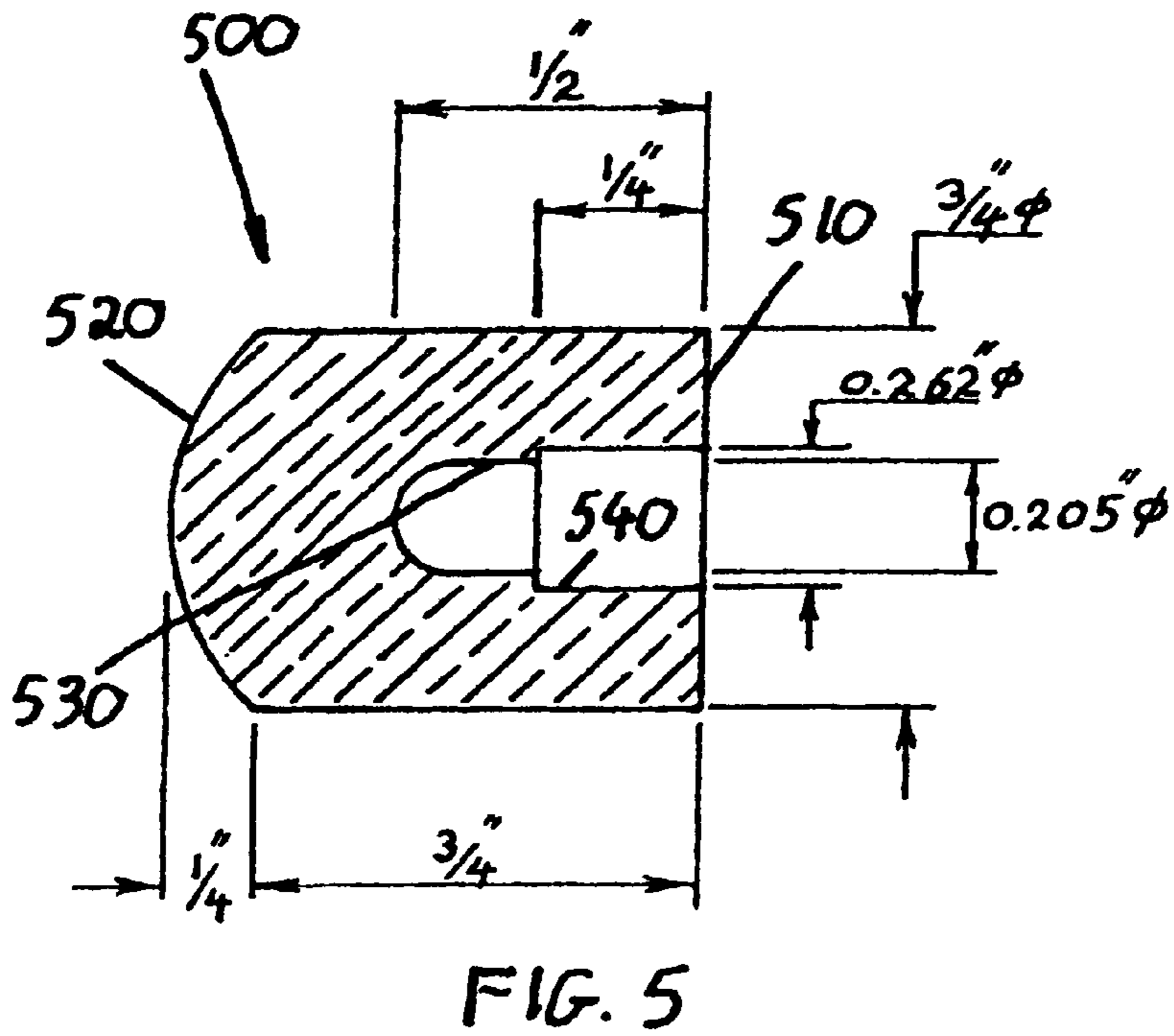
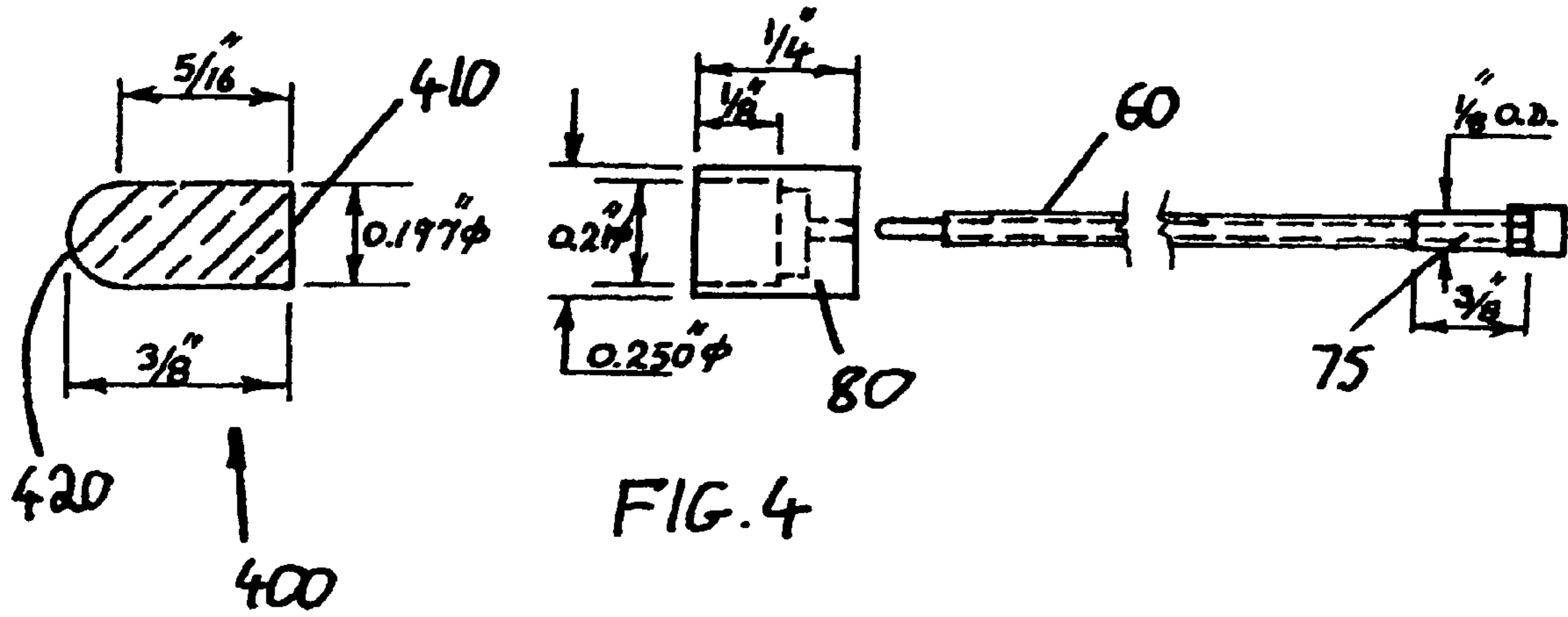
(57) **ABSTRACT**

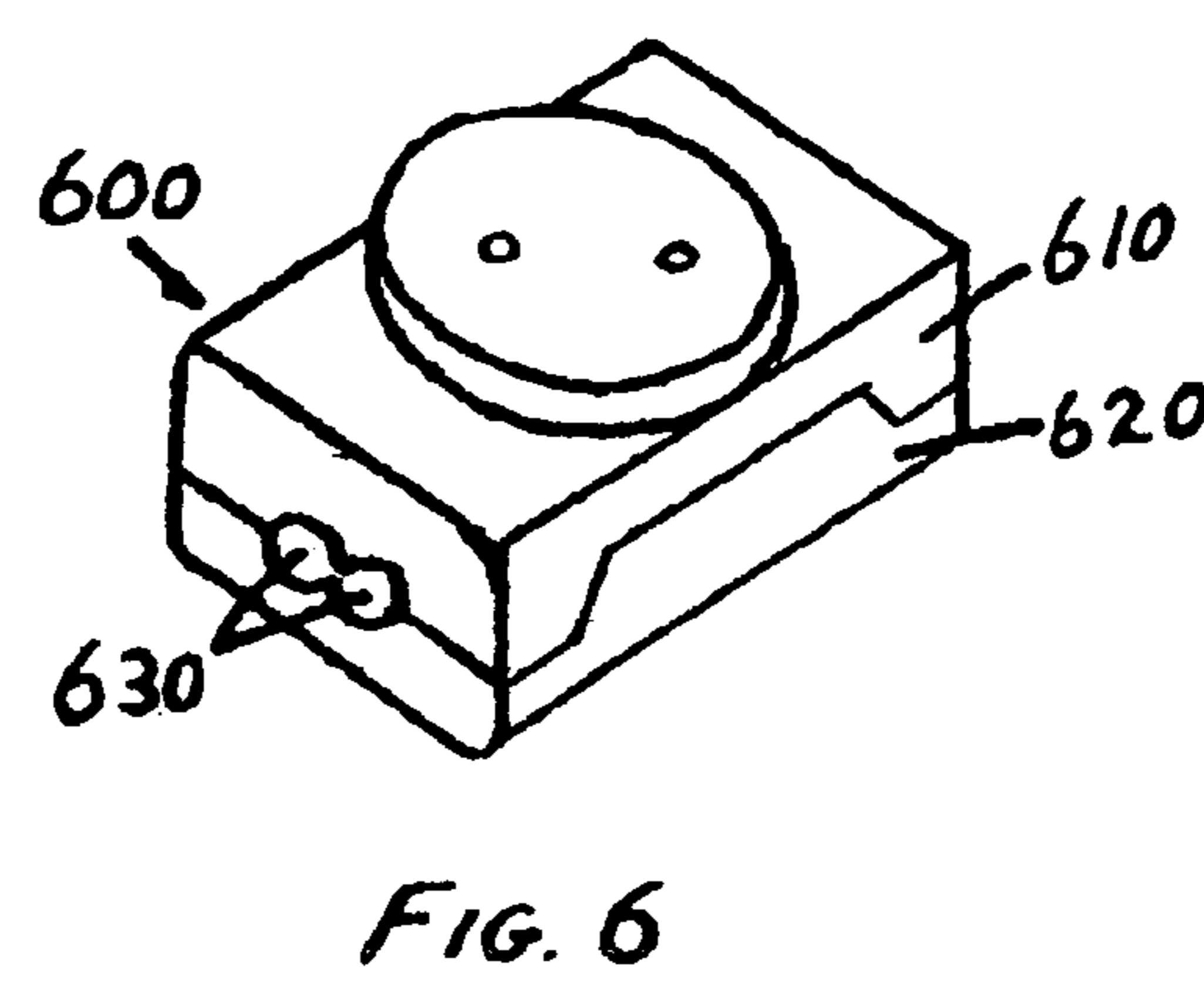
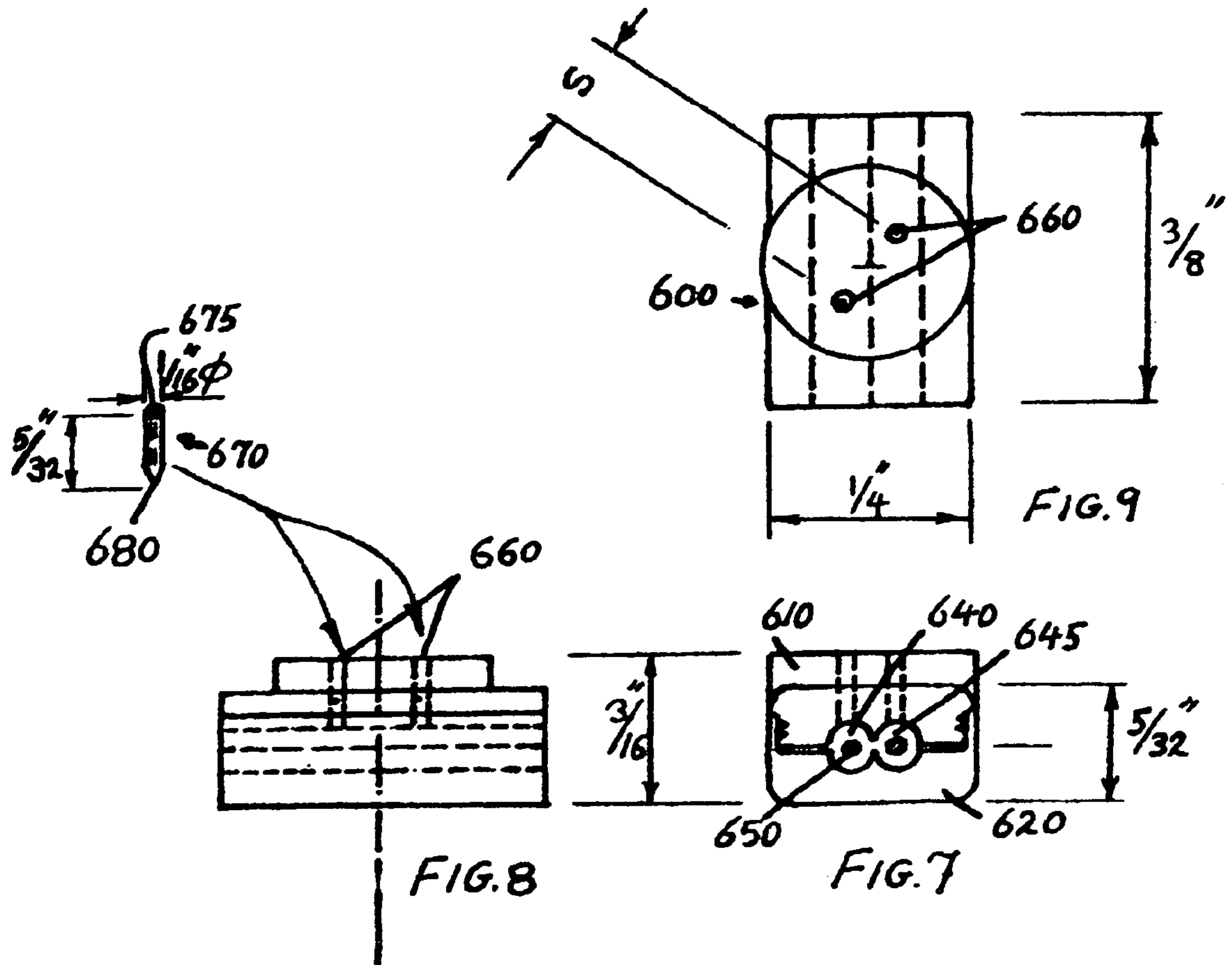
Low profile, thin panels using a layer of clear cast polymer with a reflective, mirrored backing and edges and a light diffusing face sheet, carrying light sources using fiber optic lenses or diodes on all or any sides thereof. The reflective sides direct the light beams generated at the edges toward the center and opposing sides, reflecting light beams within the cast plate, diffusing the light towards the open surface. Overall thickness of the panels is not more than 1/2" and light sources are inserted into the edging before a liquid polymer mix is cast over them, to create an integral element upon curing. The liquid polymer mix, with any additives to deliver different colors, is poured into a tray with reflective inner surface and side edges, which houses the light sources. The finished panels may have framing to cover any wiring or exposed edges.

**15 Claims, 10 Drawing Sheets**









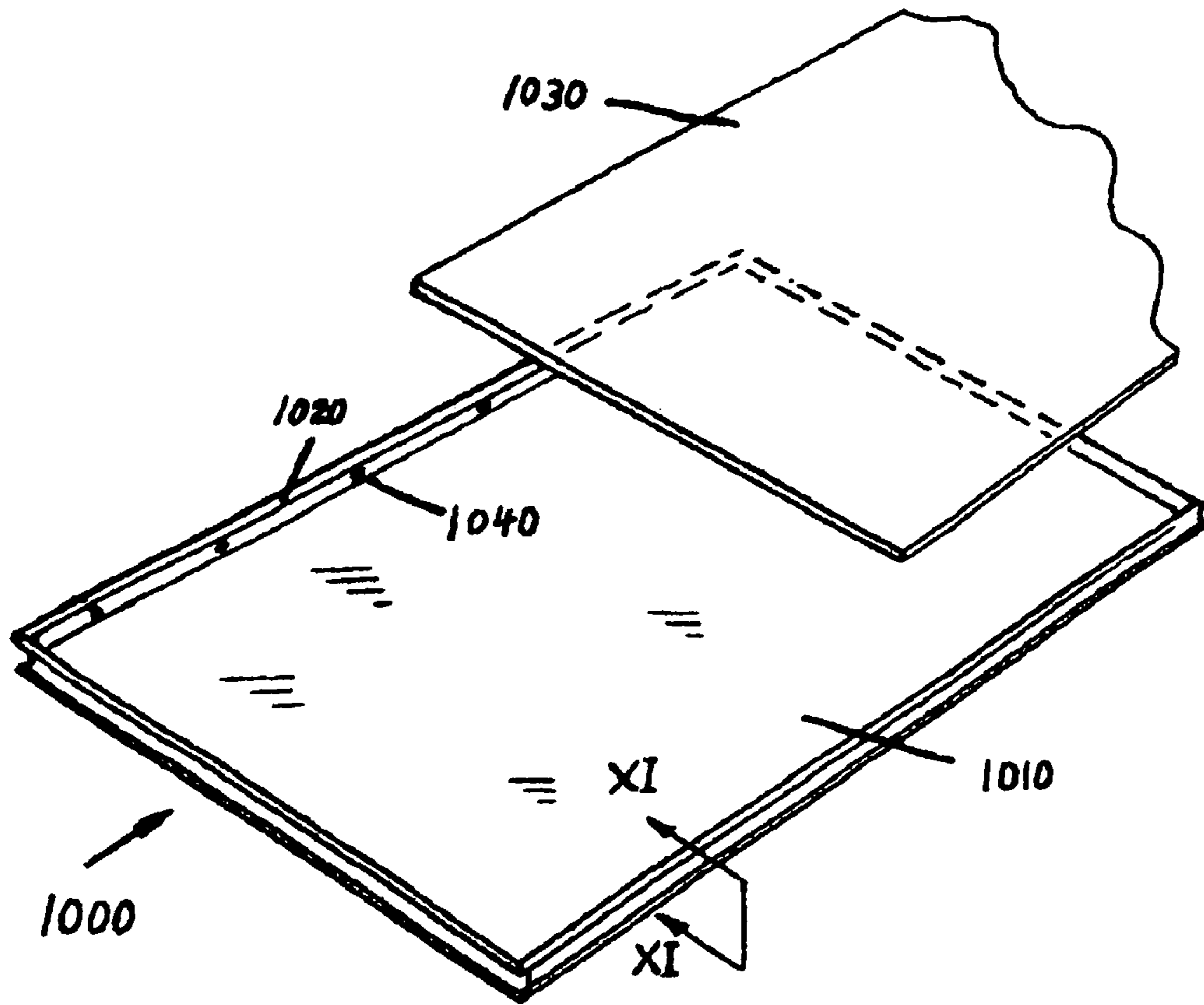
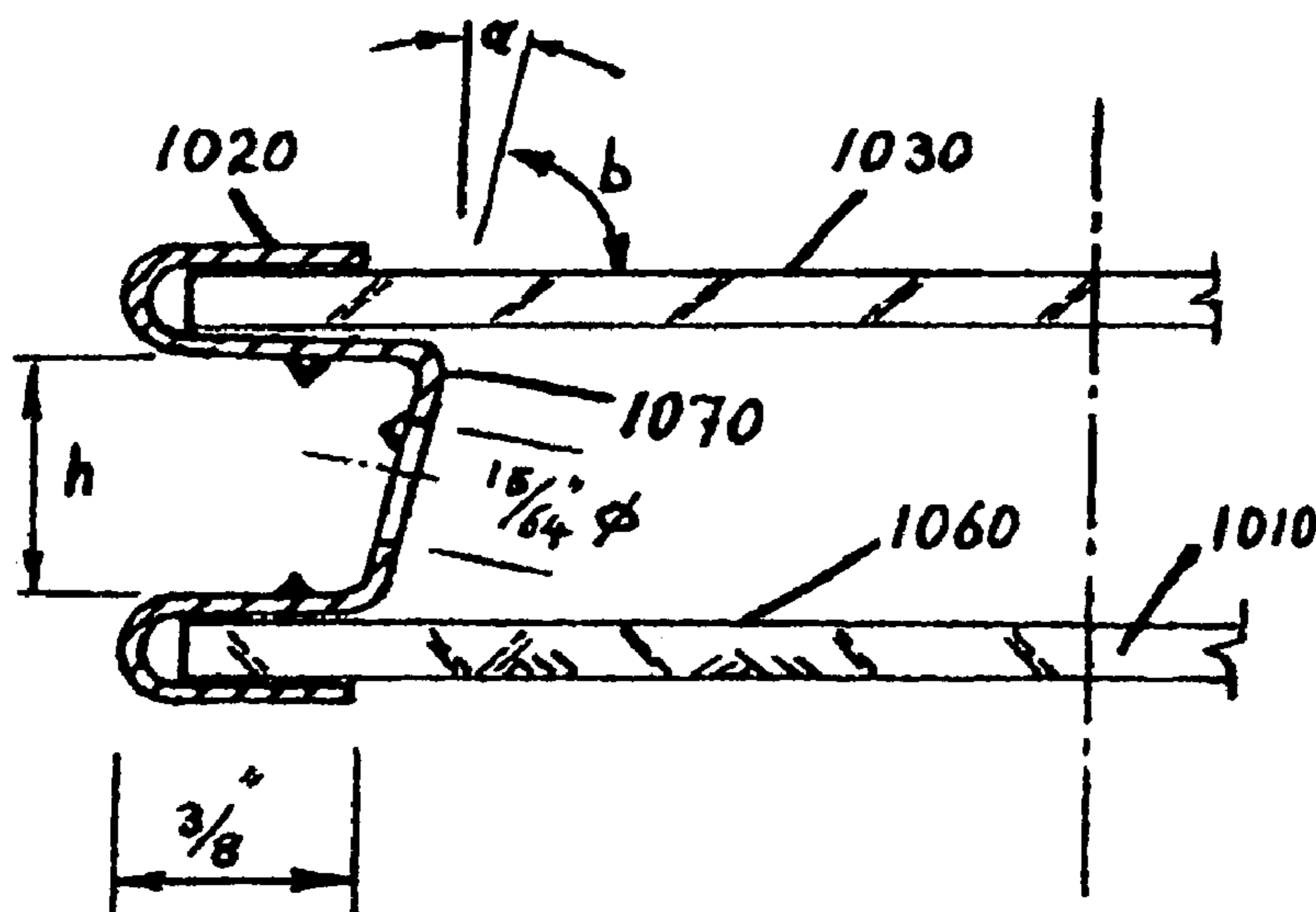


FIG. 10



XI-XI

FIG. 11



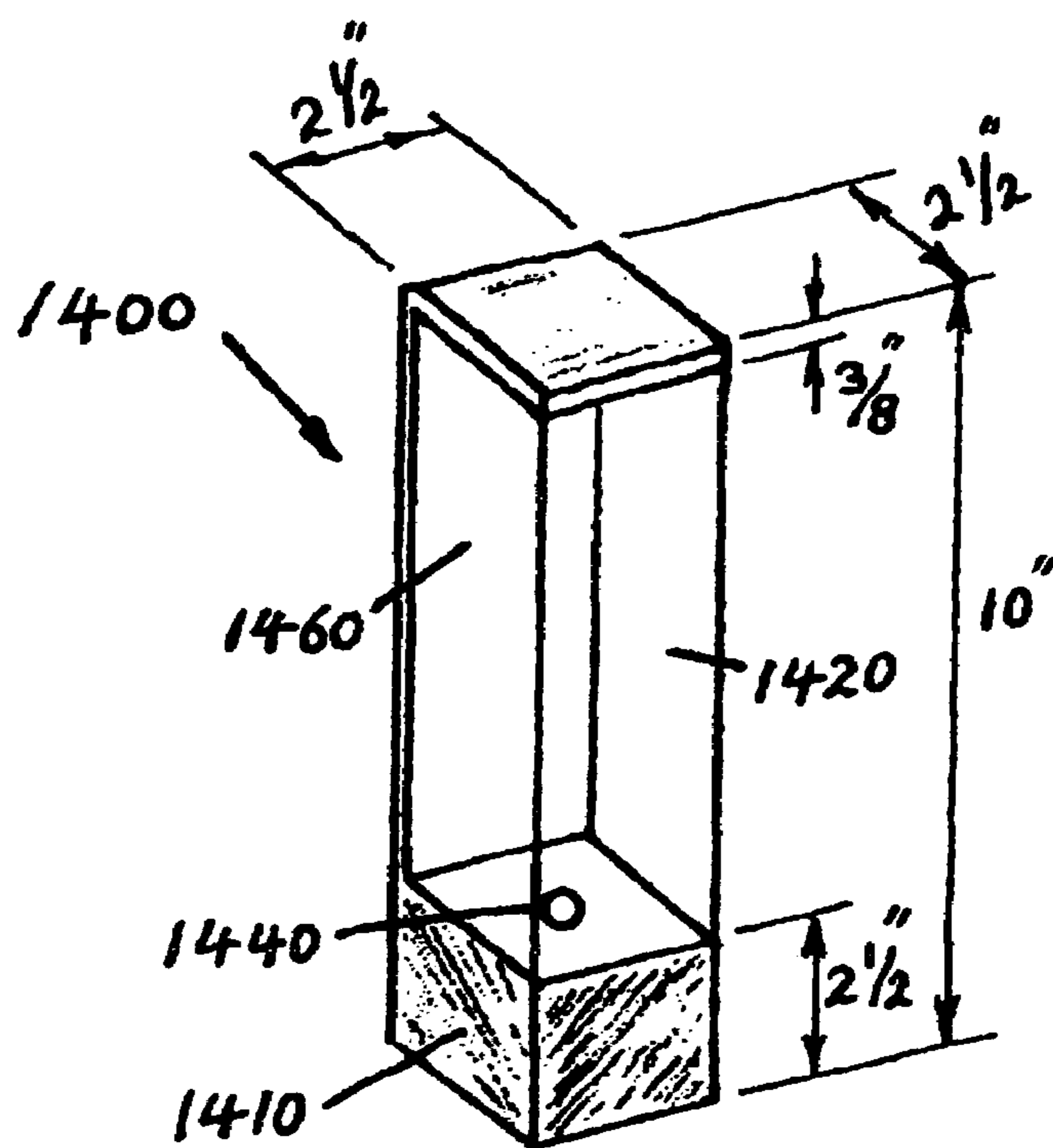


FIG. 14

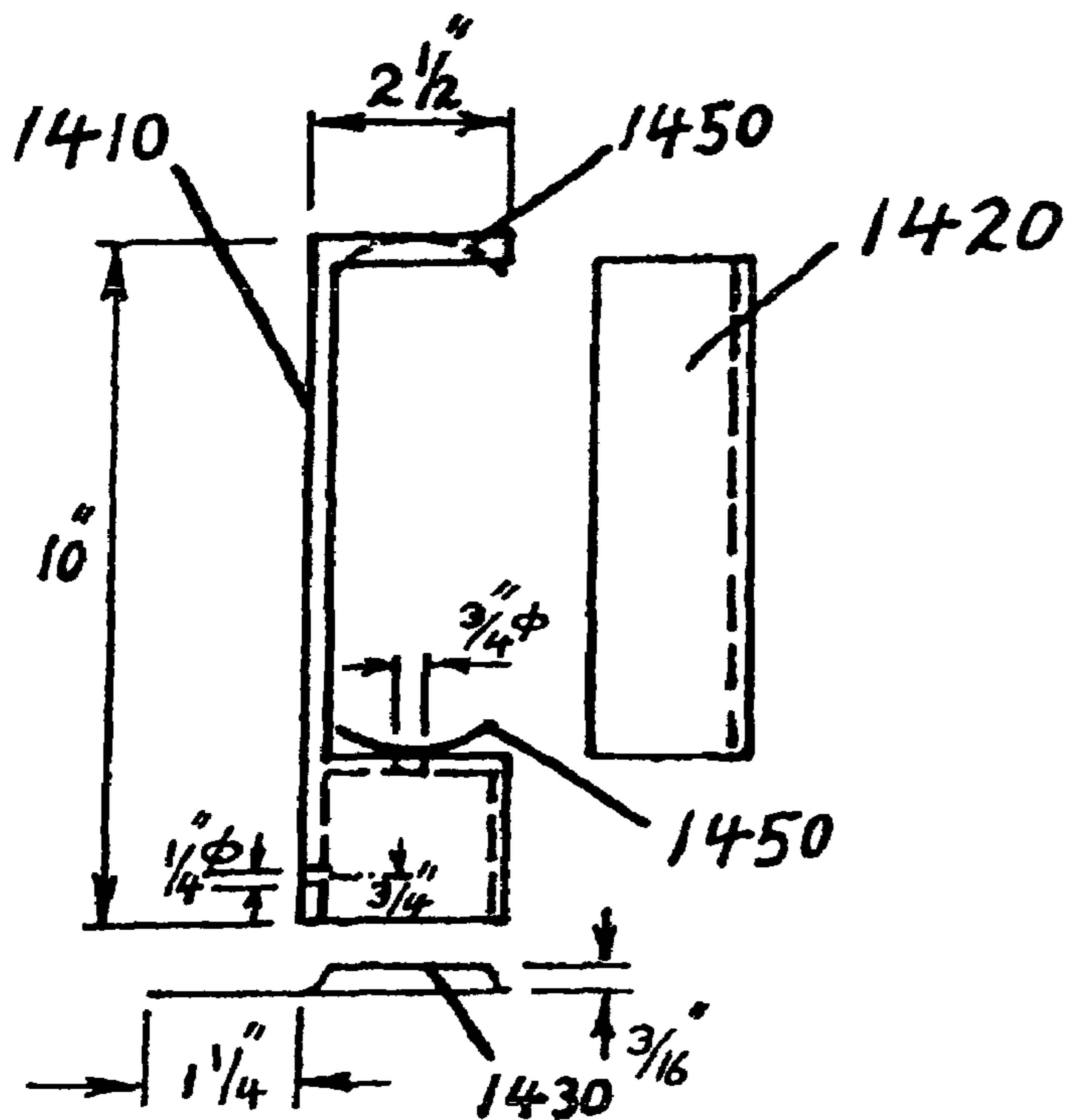


FIG. 15

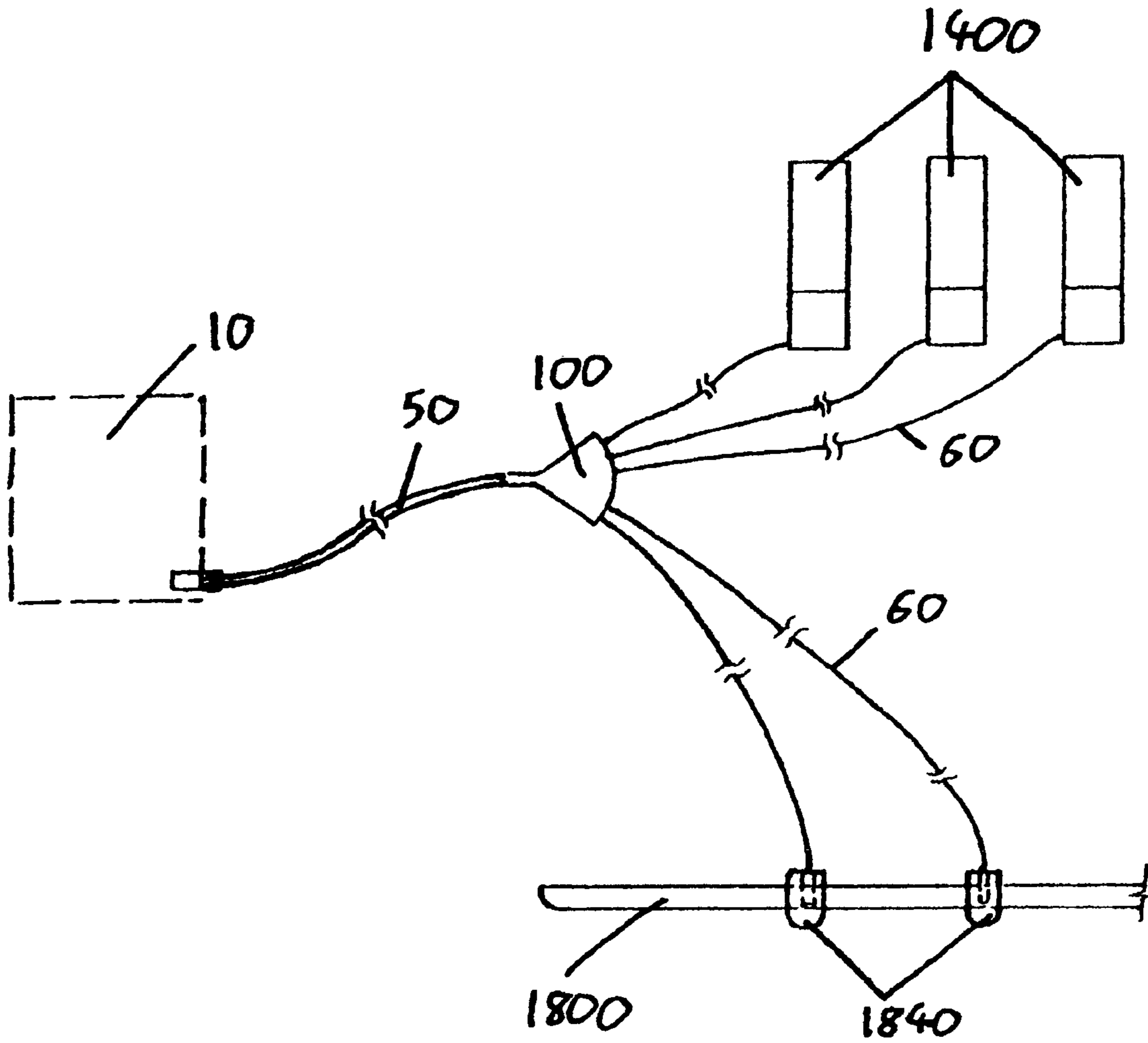


FIG. 16





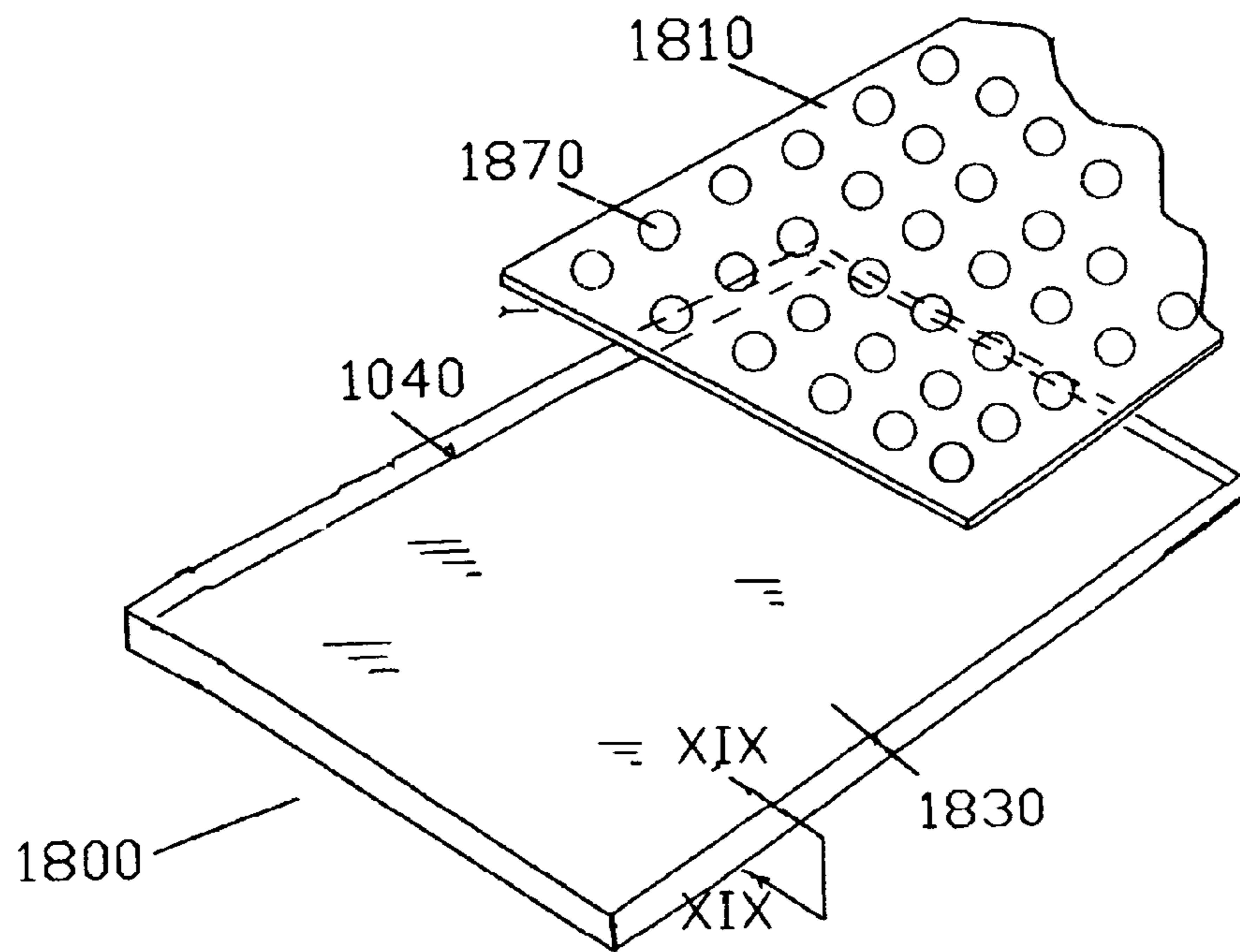


FIG. 18

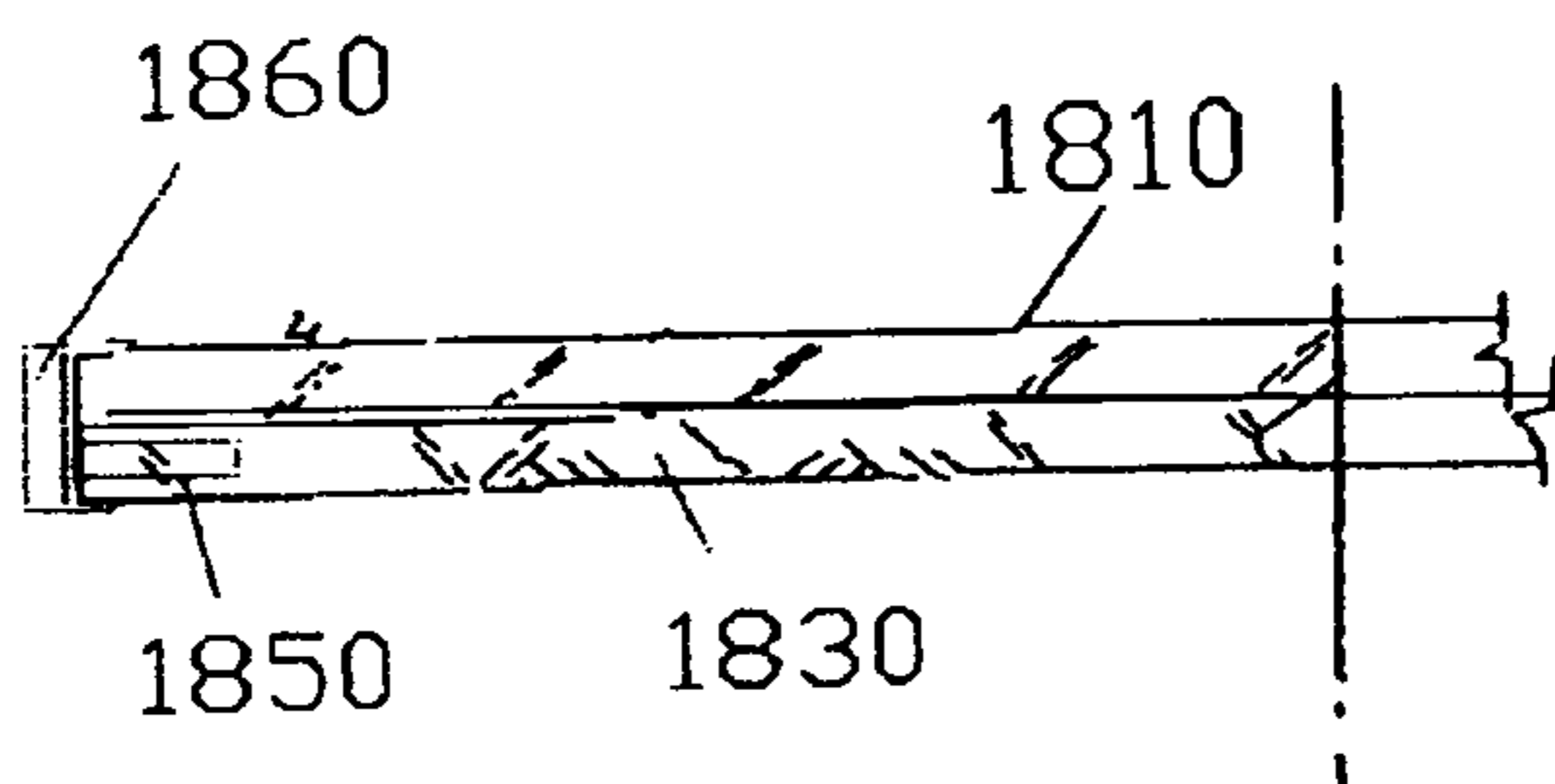


FIG. 19

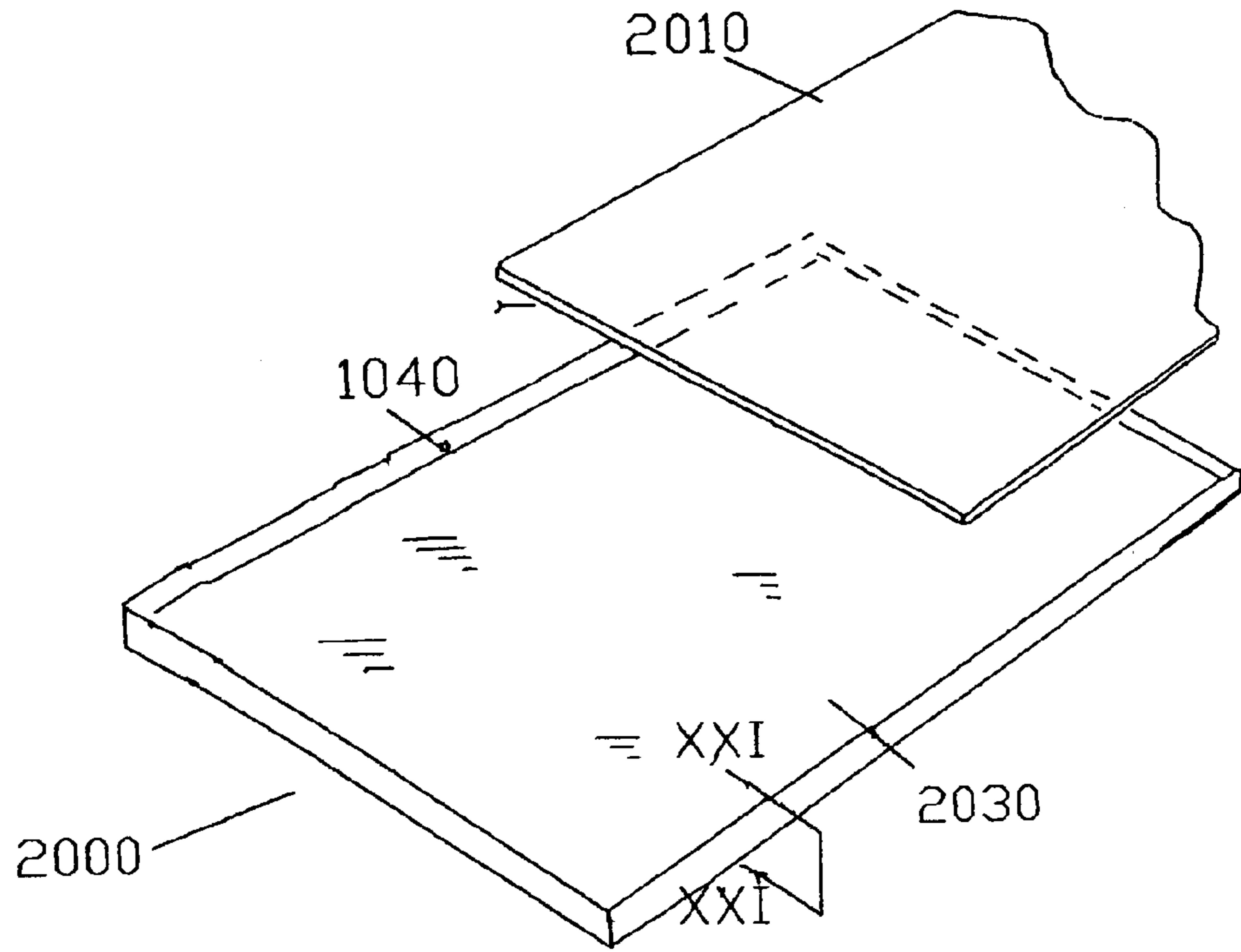


FIG. 20

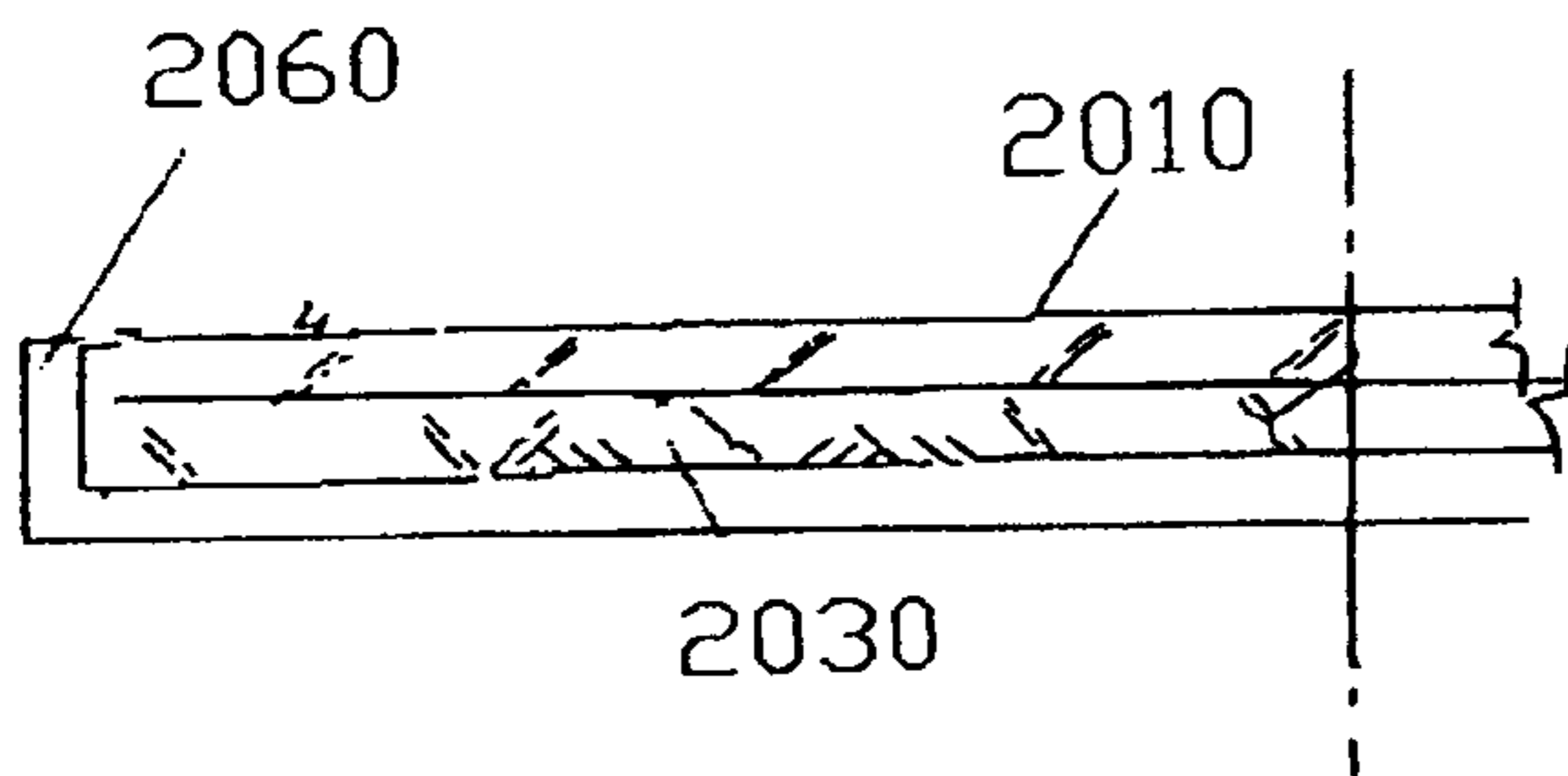


FIG. 21

**LOW PROFILE LIGHT PANEL**

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

The present invention relates to a system for lighting. More particularly: the invention relates to a system alternately employing light emitting diodes (LEDs) or a light source guided through optical fibers.

## 2. Discussion of the Background

Signs and pictures can benefit from being illuminated, either for aesthetic reasons, or for visibility. In particular, outdoor signs may need to be illuminated to be read after darkness. Almost everyone has had the experience of trying to locate a residential address after dark with only the benefit of car headlights. Illuminated signs for displaying house numbers are widely known, but have not found widespread popularity. Known signs of this type tend to be heavy, bulky and consume excessive electrical power. The householder must normally either arrange for the sign to be wired into the house electrical supply or be prepared to frequently replace batteries or bulbs. Some form of light-sensitive switching may need to be incorporated to reduce power consumption, thereby adding complexity and bulk. In addition, it is undesirable to have external electrical wiring, which is exposed to the vagaries of the weather. There is a need for house number signs that inherently consume less power, as well as for signs that can be illuminated without having electrical wiring outside the house.

The above and other disadvantages of the background art are overcome by the teachings of the present invention, as will be discussed below.

## SUMMARY OF THE INVENTION

The present invention provides for a system of object lighting that may optionally employ either multiple Light Emitting Diodes (LEDs) connected to an electrical bus via Insulation Displacement Connectors (IDC), or alternatively a central light source with light beams distributed through optical fibers via a splitter to a number of lenses providing point light sources equivalent to the LEDs.

Various lighting configurations may be achieved by the system of the invention. These include signs and pictures illuminated by point light sources arranged around a periphery thereof and configured to be reflected via a rear mirrored surface. This arrangement is particularly well adapted to illuminate house numbers, but may be used to illuminate any sign or picture.

In another aspect of the invention, a lens system is provided for point light sources, so that either LEDs or optical fiber light sources can provide the same illumination pattern. A small lens is configured to fit on the end of each optical fiber and provide the same outer curvature as a standard LED, and a larger lens is configured to fit either a standard LED or the small lens internally. In this manner, similar beams of light are produced regardless of whether LEDs or optical fibers are employed, and therefore optical fibers may be substituted for LEDs or vice versa without affecting the way the light is distributed.

In a further aspect of the invention, electrical connectors are provided to connect a plurality of LEDs to an electrical bus by displacement of the insulation. This enables a relatively large number of LEDs to be connected onto an electrical wiring harness or power supply bus with a minimum amount of wiring and a minimum number of assembly operations.

In a yet another aspect of the invention, low profile, thin panels are constructed using a single layer of clear cast polymer with a reflective, mirrored backing and edges and a light diffusing face sheet, carrying light sources using fiber optic lenses according to the invention or LEDs on all or any sides of the cast polymer. The reflective sides direct the light beams which are generated at the edges toward the center and opposing sides, reflecting an array of light beams within the cast plate, diffusing the light towards the open surface. The overall thickness of this light panel is not more than 1/2" and depending on the required overall size of the panel, a number of light sources are inserted into the reflective side edging before a liquid polymer mix is cast over them, to create an integral element upon curing. The liquid polymer mix, with any additives to deliver different colors, is poured into a tray with reflective inner surface and side edges, which house the light points—either LEDs or fiber optic lenses. The cast finished panels, encapsulating the light beam sources, may also have edge framing to cover any wiring or exposed edges of the plate

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be further described with reference to the drawings, in which like numerals designate like elements, and in which any dimensions given are by way of example.

FIG. 1 is a plan view of a fiber optical splitter according to a preferred embodiment of the invention.

FIG. 2 is a pictorial view of a fiber optical splitter according to a preferred embodiment of the invention.

FIG. 3 is an end view of a lower half of a fiber optical splitter according to a preferred embodiment of the invention, when viewed through section III-III.

FIG. 4 is a sectional side view of a small lens according to a preferred embodiment of the invention.

FIG. 5 is a sectional side view of a large lens according to a preferred embodiment of the invention.

FIG. 6 is an isometric view of an electrical connector according to a preferred embodiment of the invention.

FIG. 7 is an end view of an electrical connector according to a preferred embodiment of the invention.

FIG. 8 is a side view of an electrical connector according to a preferred embodiment of the invention.

FIG. 9 is a plan view of an electrical connector according to a preferred embodiment of the invention.

FIG. 10 is a pictorial view of a light panel according to the invention, showing a diffuser sheet removed.

FIG. 11 is a sectional view through section XI-XI of FIG. 10.

FIG. 12 is an exploded isometric view in greater detail of a light panel edging strip according to the invention.

FIG. 13 is a side view of the light panel edging strip of FIG. 12.

FIG. 14 is an isometric view of a light box according to a further embodiment of the invention

FIG. 15 is an exploded side view of the light box of FIG. 14.

FIG. 16 is a block diagram of an arrangement for distributing light beams by using the splitter of FIGS. 1-3.

FIG. 17 is a detailed view showing the use of the small lens of FIG. 4 with the splitter.

FIG. 18 is a view of a further embodiment of the light panel.

FIG. 19 is a sectional view through section XIX-XIX of FIG. 18.

FIG. 20 is a view of yet another embodiment of the light panel.

FIG. 21 is a sectional view through section XXI-XXI of FIG. 20.

#### DETAILED DESCRIPTION OF THE DRAWINGS

A light panel 1000 according to a preferred embodiment of the invention is shown in FIG. 10. Light panel 1000 includes a mirrored back sheet 1010, an edging strip 1020, a frontal diffuser sheet 1030 and a plurality of point light sources 1040. The diffuser sheet 1030 is shown removed from the light panel 1000 in this view for clarity. FIG. 11 shows the light panel 1000 fully assembled, but without point light sources 1040, when viewed on section XI-XI of FIG. 10. Both the diffuser sheet 1030 and the mirrored back sheet 1010 may be made from acrylic, or from any other suitable material. Point light sources 1040 are inserted in apertures 1050 in edging strip 1020. Edging strip 1020 is preferably made of rust proof steel with a Chrome plated or otherwise mirrored inner surface 1070, but may be made from other suitable materials without departing from the scope of the invention.

In an alternative embodiment of the invention, the material of the diffuser sheet 1030 may be cast in place around the point light sources 1040 by pouring clear acrylic liquid into the frame formed by the edging strip 1020 and the backing sheet 1010. Preferably, the clear acrylic liquid contains 1% Titanium Dioxide. Titanium Dioxide is pure white, and will reflect the light beams travelling along the acrylic sheet, causing the beams to come out of the acrylic sheet and giving a uniform spread of the light beams. The light panel 1000 formed by this method and with this composition provides a uniform non-glare backlighting surface. Other coloring materials can be substituted in place of Titanium Dioxide to give you different color light surfaces.

The edging strip 1020 is arranged to overlap the diffuser sheet 1030 and the backing sheet 1010 by a distance 'd', which in a non-limiting example may be 0.375 inches, and an inner surface 1070 of edging strip 1020 is angled downwards by an angle 'a'. Angle 'a' is preferably in the range 10-15°, preferably substantially 12°, i.e. angle 'b' would be substantially 78°, such that light from point light sources 1040 is reflected from mirrored surface 1060 of back sheet 1010 towards diffuser sheet 1030. As the point light sources 1040 are arranged to emit light normal to the inner surface 1070, the angle of incidence of the light with respect to the mirrored surface 1060 of the backing sheet 1010 is also equal to the angle 'a'. The diffuser sheet 1030 may be covered by a further sheet acting as a mask (not shown), which does not permit the passage of light except through selective openings, such as cut out numerals and/or letters, for example to display a house number or other message. In an alternative embodiment, the light panel may be used as a picture frame and the mask may be the mat used in framing the picture. This results in an appealing backlighting effect.

Angle 'a' may, of course, be varied outside of the range from 10-15° without departing from the scope of the invention. Inner surface 1070 of edging strip 1020 is also preferably mirrored to maximize internal reflection of the light. This arrangement allows height 'h' in a non-limiting example to be as low as 0.675 inches, which is significantly less than the thickness of light panels known in the background art. Point light sources 1040 may be interchangeably provided either by LEDs or by lenses connected by optical fibers to central light source 10.

FIG. 12 shows edging strip 1020 in greater detail, in an exploded view together with cap 1080 and mounting bracket 1090, and FIG. 13 shows a side view of edging strip 1020. Tabs 1075 are provided on the same centers as holes 1050, preferably at a spacing of 1 inch, although the spacing may be varied without departing from the scope of the invention. Brackets 1090 are provided with holes 1095 for receiving tightening screws (not shown) and are used to retain edging strip 1020 at the corners of light panel 1000. When the corners of light panel 1000 are assembled, brackets 1090 are placed such that screwing the tightening screws into holes 1095 will push brackets 1090 against the inside of ridges 1085 in edging strip 1020. Brackets 1090 may be made of steel or any other suitable material. Tabs 1075 may be folded to secure backing sheet 1010 when the light panel 1000 is assembled. Cap 1080 may be made of any suitable plastic or other material, and serves both to finish the appearance of lighting panel 1000 and to cover the wiring or optical fibers leading to point light sources 1040.

In another embodiment of the invention, light panel 2000 is made by pouring the clear acrylic liquid or other suitable settable material into a tray 2060, having reflective inner surfaces, instead of into edging strip 1020 and backing sheet 1010. In this embodiment of the invention the settable material would preferably contain Titanium Dioxide in an amount ranging from 0.005 to 0.05% for different desired effects, preferably 0.02%. In this embodiment, the acrylic material would be cast in place around the point light sources 1040, which would be positioned around the edges as before. This forms an acrylic layer 2030, and the only additional is diffuser sheet 2010, preferably made of either paper or a suitable thermoplastic material, which is applied to the side opposing the base of the tray 2060. The overall thickness of the resulting structure could be about a quarter of an inch.

In another alternative embodiment, as for example shown in FIG. 18 and FIG. 19, the light panel 1800 comprises a diffuser sheet 1830, which may for example be made of acrylic that may be only a quarter of an inch thick, and has holes 1850 cut at the edges to house point light sources 1040. This embodiment eliminates the use of the edging strip 1020. Small holes 1850 are drilled into the edges of the diffuser sheet 1830 and polished at their edges. Point light sources 1040, for example LEDs, are then inserted into these holes, the refractive index being matched, for example, with indexing liquid gel. Light from the point light sources 1040 is transmitted across the diffuser sheet 1830. The edges of the diffuser sheet 1830 may be covered with a reflective tape 1860 to trap the light beams within the diffuser sheet 1830. A backing sheet 1810 having a reflective surface is provided on the back of the diffuser sheet 1830. The backing sheet 1810 is preferably in the form of a Mylar sheet with small white dots 1870 printed on one side of it, the white dots 1870 facing the diffuser sheet 1830. Some of the light beams transmitted through the diffuser sheet 1830 will travel at an angle out of the media and get bounced back by the backing sheet 1810, and some white spots 1870 will reflect the light beams back into the diffuser sheet 1830.

In one embodiment, LEDs may be used for each point light source 1040. Power for the LEDs may be derived from the mains wiring, or from rechargeable batteries connected to a solar cell, or from any other suitable source. Conventionally, this has involved soldering two wires to each LED, which has necessitated a large number of separate soldering operations to assemble a lighting system employing multiple LEDs.

In a preferred embodiment, the present invention overcomes this problem by using low-profile connector **600**, as shown in FIGS. **6**, **7**, **8** and **9**. Connector **600** includes an upper part **610** and a lower part **620**, which may be molded from a non-conductive thermoplastic such as ABS, or otherwise formed from any suitable material. When upper and lower parts **610** and **620** are assembled together, as shown in the drawings, two cylindrical recesses **630** are formed, through which a wiring harness having two insulated wires **640** may be passed, each including an insulation layer **645** surrounding an inner conductor **650**. The inner conductors **650** may be, for example 24 AWG. Upper and lower parts **610** and **620** may, for example, be snapped together by using a simple hand tool (not shown).

Two holes **660** are provided in upper part **610** of connector **600**, into which pins **670** are inserted. Holes **660** are placed in a staggered relationship relative to wires **640**, so that the spacing 's' is equal to the spacing between the leads of the LED, for example 0.1 inches. A single pin **670** is shown removed from hole **650** in FIG. **8**, and is hollow, with a central aperture **675** extending from an upper end, and a point **680** at a lower end thereof. The central aperture **675** is sized to receive a lead of an LED as a push fit, and the pins are configured to be a push fit into holes **660**. Pins **670** may be made of brass or any other suitable material. The leads of an LED (not shown) are inserted into central apertures **675** in pins **670**, which are then inserted through holes **660** in upper part **610** of connector **600**, and the points **680** of pins **670** penetrate the outer insulation layers **645** of wires **640**, to make contact with the inner conductors **650** thereof. In one example, the overall size of the connector **600** is 0.25 inches wide and 0.1875 inches high.

Large lens **500** shown in FIG. **5** has a planar rear surface **510** and a convex front surface **520**. Front surface **520** has substantially the same curvature as inside surface **530**, which is configured to mate with front surface **420** of small lens **400**. Surfaces **520** and **530** are highly polished. Inner cylindrical surface **540** of large lens **500** is configured to have a particular diameter so that both the optical fibers and the ferrule of a standard LED are a push fit. Thus, either a small lens **400** (see FIG. **4**) or a standard LED may be interchangeably push fit into large lens **500**, and in both cases the focal point of the large lens **500** substantially coincides with the focal point of the light source.

FIGS. **14** and **15** show a light box **1400** according to an embodiment of the invention. Light box **1400** includes a holder **1410**, a clear cover **1420**, an end cap **1430**, a light source **1440** and top and bottom reflective dishes **1450**. Holder **1410** is preferably made from black brushed Aluminum, but may be made of any other suitable material, and has a reflective back-plate **1460**. Top and bottom reflective dishes **1450** may, for example, be made of a suitable plastic with a reflective metal coating. The clear cover **1420** may be made of plexiglass or the like, and the end cap may be an Aluminum stamping, although other materials may be used. Each light source **1440** may include a large lens **500** inside which is inserted either an LED or a small lens **400** connected via optical fibers to a central light source **10**. Multiple light boxes **1400** may, for example, be used for outdoor landscape lighting, or for indoor decorative lighting. These may be connected as shown in FIG. **16**.

In an alternative embodiment of the invention, illustrated in FIG. **16**, a central light source **10**, which may be a halogen lamp or any other suitable light source, is used to illuminate a first end of a bundle of optical fibers **50**. The fibers are then separated in a splitter **100**, and strands of optical fibers **60** are

fed to light boxes **1400** or to lighting strip **1800** as appropriate, as will be discussed further.

Splitter **100** is shown in more detail in FIGS. **1**, **2** and **3**. Splitter **100** may be constructed in upper and lower halves **110**, **120**, fastened together by screw **130** located in aperture **135**, or by any other suitable means. The bundle of fibers **50** from the light source **10** enter the splitter **100** through input aperture **140** and exit through a plurality of output apertures **150**, thereby splitting the light from the light source. The optical fibers are additionally aligned by apertures **160** in web **170**.

FIG. **17** shows in more detail how each fiber strand **60** passes first through an aperture **160** in the web **170** in the splitter **100** (only part of which is shown), then through a ferrule **70** which protrudes through a hole **150**. Ferrule **70** may be made of brass or any other suitable material, and is retained in place by web **170**. Coupler **75** mates with ferrule **70**, and is connected through fiber strand **60** to a small lens **400** retained in a lens assembly **80**. Small lens **400** may in turn be inserted in large lens **500** as shown.

Small lens **400** is shown in more detail in FIG. **4**. The end of the fiber **60** and the rear surface **410** of small lens **400** are each polished before they are coupled together, e.g. with a suitable optical adhesive in lens assembly **80**. The front surface **420** of small lens **400** is also highly polished and has a convex curvature the same as that of a standard LED to be used in other embodiments of the invention. The small lens **400** therefore has a center of focus which is not only suitable for use with large lens **500** shown in FIG. **5**, but is also suitable for use with a standard reflector (not shown) that is readily available and is designed to have a standard LED placed in the center thereof.

It is often desirable to illuminate an object without illuminating the surroundings. For example, to enable a stair tread to be located without lighting an entire room. FIG. **16** shows a lighting strip **1800** according to another embodiment of the present invention, which can be used for this and other similar purposes. Lighting strip **1800** includes a row of point light sources **1840** that may be either LEDs or small lenses **400**. Lighting strip **1800** may be connected to central light source **10** via splitter **100** as also shown in FIG. **16**.

It will be appreciated by one skilled in the art that numerous variations and modifications are possible, and that the invention may be practised otherwise than as specifically disclosed herein, without departing from the spirit and scope of the invention.

What is desired to be claimed in letters patent is:

1. A light panel comprising:
  - a backing sheet provided with a reflective surface;
  - edging strips connected to the periphery of the backing sheet and with the backing sheet forming a tray;
  - point light sources supported by the edging strip; and
  - a light panel surrounding and encasing the point light sources formed by pouring settable material into the tray formed by the backing sheet and the edging strips and allowing the material to set.
2. The light panel of claim 1 wherein:
  - said settable material comprises a clear acrylic.
3. The light panel of claim 1 wherein:
  - said settable material comprises a coloring agent.
4. The light panel of claim 3 wherein:
  - said coloring agent comprises Titanium Dioxide.
5. The light panel of claim 4 wherein:
  - said settable material comprises Titanium Dioxide in a proportion of between 0.005 percent and 2 percent.

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- 6. The light panel of claim **5** wherein:  
said settable material comprises substantially 1 percent  
Titanium Dioxide.
- 7. The light panel of claim **5** wherein:  
said settable material comprises substantially 0.02 percent 5  
Titanium Dioxide.
- 8. The light panel of claim **1** wherein:  
said point light sources are light emitting diodes.
- 9. The light panel of claim **1** wherein:  
said point light sources are lenses illuminated via optical 10  
fibers.
- 10. The light panel of claim **1** further comprising the step  
of:  
applying a diffuser sheet to the light panel after the  
material has set.

**8**

- 11. The light panel of claim **10** wherein:  
said diffuser sheet comprises paper.
- 12. The light panel of claim **10** wherein:  
said diffuser sheet comprises thermoplastic material.
- 13. The light panel of claim **1** further comprising the steps  
of:  
covering said edging strips with a reflective material.
- 14. The light panel of claim **13** wherein:  
said reflective material comprises a plurality of white  
dots.
- 15. The light panel of claim **13** wherein: said reflective  
material comprises mylar.

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